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Limitations of current fetal monitoring technology

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1 Introduction

The word monitoring is universally used wrongly by obstetricians. If the Oxford English Dictionary is consulted there are quite a number of definitions. The one relevant in this context is something which gives warning.

Unfortunately, the machines used are correctly called cardiotocographs, and provide only continuous recordings. They do not monitor and yet are referred to quite erroneously as monitors. For many years midwives and obstetricians have listened to the fetal heart with the Pinard stethoscope and this has usually implied monitoring because there is some cerebral processing, we hope, going on. The attendants will sound warnings if they feel the information they are getting is outside normality. It does however have disadvantages. Everyone has had experience of a fetal heart being reported as present and yet shortly thereafter the fetus is delivered in a macerated state. It is for this reason that Pinard stethoscopes have been banished from the labor ward in Ninewells and replaced with ultrasound machines operating on the Doppler principle thus allowing the attendant, the patient or anyone in the vicinity, to hear (or not to hear) the fetal heart. This however does not overcome another problem — the inaccuracy with which people can count the frequency. HON showed many years ago [4] how inadequate this was, especially when a fetal heart was outside the normal range: either very slow or very fast. It was for this reason amongst others, that HON developed the technique for continuous recording of the fetal heart rate. Unfortunately he continued to use the beats per minute concept familiar to clinicians for the new concept of instantaneous heart rate intervals. Subsequently it was too late to change the measurement of the R to R interval from a frequency to a period expressed in milliseconds which was desirable to avoid the probability of a single beat to beat measurement being confused with an average fetal heart raae. It is still a constant problem to make doctors and midwives properly comprehend the essential

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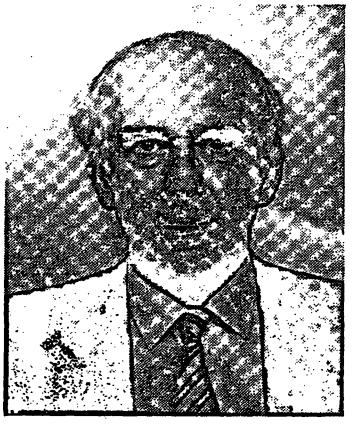

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difference between these two. It was a major though understandable error on HON's part. Understandable because he used familiar terminology albeit misleadingly, to gain acceptance.

2 Limitations of the technique

When talking about the current fetal monitoring technology limitations, it is necessary to point out the physiological limitations of the technique. There are very many different reasons why the fetal heart rate should change [1] and the clinician has to guess which of the many causes may have caused a slowing or accelerating of the fetal heart. It must be remembered that however detailed the analysis, it is a physiological impossibility to make an absolute diagnosis of etiology in all cases from the pattern of the fetal heart rate and no improvement in technology will alter that fact. With that in mind, the limitations of the technology at present used can be discussed.

Limitations can be discussed under various headings.

2.1 Data capture

Various techniques are used, and they have improved with time, to detect the R to R interval. Ringing filters which grossly distort the ECG have been used to decrease noise but in spite of them artefactual spikes can still often cause spurious generation of a synchronous pulse from which the monitor derives the frequency and many instruments have very little in the way of signal validation checks. The much poorer ultrasound signal has comparatively recently been much improved by the technique of auto-correlation which allows a much more accurate recognition of the true frequency although by its nature it can never be quite as accurate as the rate derived from the ECG.

2.2 Data validation

Data validation was improved when our system was developed [3] and the ECG signal was sampled a 1000 times per second a considerable load on the then computer hardware and necessitating assembly language programming because with the artifactual nature, at that time, of many of the signals even althouth it was only the R to R interval which was wanted it was desirable to know how valid that signal was.

Thus it was possible to display, at any time, the reliability of the signal. Indeed, if more than 15% in any one monitoring period was lost no information was given to the clinician. This was the opposite approach from the manufacturers who, for marketing reasons, attempted to clean up the signal using considerable technological ingenuity in doing this and therefore selling the machine on the basis that it was much better at picking up signals than the rival machine. This rival was often giving a truer picture and we have a major educational problem in teaching people that poor signals should not be taken into account at all. (This also applies to pH and indeed all measurements).

2.3 Data analysis

Data analysis is the crucial and difficult problem we have to face in fetal monitoring. At present it is done by „eye-balling": an American expression which is used here as a term of abuse for the process. If the analysis of a recording is going to be any good it has to be systematically examined by the individual doing it who has been suitably trained in being systematic about it and trained how to recognize abnormalities and what they may mean and what action should be taken. By whom should this eye-balling be done? It has to be done by the person or persons present in the labor ward which means medical students, student midwives, staff midwives with midwifery sisters from time to time and doctors occasionally. This entails an enormous training programme which is never ending, expensive and time consuming and therefore badly done in the better units and appallingly done in the poorer units. The problem to get the recorder to act as a monitor is that the early crude attempts at alarm generation were based on crude data analysis and the

Table I. Model of data analysis.

Epoch	Baseline	Scatter	Comment	Quality	Alert	Pressure
11.15	144	125–156	none	good	green	no contr
11.25	138	116–150	none	good	green	no contr
11.35	145	126–157	none	good	green	weak
11.45	143	130–181	acclns	good	green	moderate
11.55	147	135–185	declns ? type	mod	green	moderate
12.05	145	84–156	declns early	mod	yellow	strong
12.15	144	86–160	declns late	mod	yellow	strong
12.25	141	76–155	declns late	mod	yellow	strong
12.35	137	65–149		mod	yellow	strong
12.45	?131	signal quality too poor for analysis				
12.55	signal lost					

methods used were so simplistic that the process fell into disrepute both ways. Too many alarms were called and on occasion true alarms were not initiated. These alarm options were soon switched off. Unfortunately, in spite of newer techniques, no attempt was made to apply them.

It was possible sometime ago [3] to apply techniques of computer analysis to fetal heart rate and intrauterine pressure and to generate not just alarms but comments in English which also gave green, yellow and red alerts (table I).

The red alert almost never and the yello warning occurred relatively infrequently and the table shows the kind of printout every ten minutes the computer could generate on a labor.

2.4 Data presentation

The miles and miles of pen tracing generated throughout the country in every labor ward that is continuously recording, presents a daunting task for real-time clinical management, still more for any of the other important uses for which the information may be put. This was recognized in the sixties by workers such as KUBLI [5] who had already complained about how many kilometers of pen tracing they had in their clinics. The expert finds it difficult enough with all these data much of it irrelevant, the inexpert often miss important findings because of the sheer amount of normal information with which they are presented.

2.5 Data reduction

There are many methods of doing this. One approach once the data are analyzed was not to display normal data. It is possible to call attention to unreliable signals and allow the staff to correct this and to call attention to unusual and the rare alarm data. An analysis of a large number of ten minute epochs of labor [3] disclosed that about 75% of the information displayed would have been so normal as to excite no interest in any clinician and this was in induced patients and therefore probably above average. It is more than probable if poor signals were excluded that more than 90% of the information could be ignored without losing anything useful. So called interesting epochs were anything abnormal e. g. decelerations, poor variability, when the baseline could not be calculated by the computer and when the signal was of poor quality. Thus it is apparent that it would not be difficult to get rid of a very large amount of the data presentation by data reduction and attract the attention of (but not alarm) the clinician only when necessary and not overwhelm him with a mass of unnecessary data.

2.6 Data archiving

The present recorders have no satisfactory method of data archiving. This is ridiculous considering the modern methods of storing data.

Depending upon the requirements of the hospital these data can be archived in the raw state or in a data reduced state. The main justification for the raw state would be for research purposes. Obviously recording in the raw state would require fairly large amounts of storage although this is becoming less and less expensive. It is because of this that adequate audit of the various possible clinical managements is unsatisfactory in most units.

2.7 Audit

It is extremely difficult to go through the case notes and pull out pen tracings then audit large numbers of these without entailing vast expense. It means using Medical Records personnel to pull notes and clinicians to analyze tracings, assuming they are where they should be in the notes. The alternative system of putting tracings in boxes separate from the notes means that they are subsequently almost impossible to find for individual patients. All these problems should be easily overcome with modern electronic filing.

2.8 Data transfer

If the information is processed as described it can be easily transferred for analysis by other people. Thus nationwide experience could be audited. Even in real time, expert opinion can be sought as was demonstrated was possible some years ago [2].

3 Conclusion

We in the profession have failed to demand, and the manufacturers to offer the advantages of modern technology which could improve our level of intra-partum care.

There is considerable scepticism by many both in the United Kingdom and the United States about the benefits intra-partum monitoring has achieved in terms of fetal mortality and morbidity. There are many reasons for this but one is surely the poor clinical monitoring of the continuous recording.

I hope the Nottingham meeting will help to make both the labor ward attendants and the manufacturers aware of these serious shortcomings in all their present cardiotocographs.

Summary

Continuous recordings with a cardiotocograph are confused with the concept of monitoring. One of the continuing problems is ensuring that recordings are properly monitored by the clinical staff. Previous simplistic attempts at producing true monitors which failed to work inhibited the development of more sophisticated approaches which modern technology now make possible. The use of computers in this field would not only reduce the monitoring load on the staff but also have advantages in data storage, data transfer and in audit. The profession has failed to demand, and the manufacturers to offer, the advantages of modern technology which could improve our level of intra-partum care.

Keywords: Audit, auto-correlation, cardiotocograph, computer, monitoring, R-R interval.

Zusammenfassung

Grenzen der gegenwärtigen Technologie beim fetalen Monitoring

Die kontinuierliche Überwachung mit einem Kardiotokographen wird fälschlicherweise mit dem Konzept der fetalen Überwachung gleichgesetzt. Eines der ständigen Probleme, die sich daraus ergeben, besteht darin sicherzustellen, daß die Aufzeichnungen durch das klinische Personal richtig überwacht werden. Die Entwicklung hochspezialisierter Geräte, für die heute die Technologie bereitsteht, ist durch die früheren erfolglosen Versuche, adäquate Monitoren herzustellen, behindert worden. Der Einsatz von Computern auf diesem Gebiet würde nicht nur das Personal entlasten, sondern auch hinsichtlich der Datenspeicherung, des Datentransfers und der Datenprüfung Vorteile liefern. Von seiten der Mediziner fehlte die Nachfrage, von seiten der Hersteller das Angebot von Geräten, die der modernen Technologie Rechnung tragen und so das Niveau der intrapartualen Überwachung verbessern.

Schlüsselwörter: Autokorrelation, Computer, Datenprüfung, Kardiotokograph, Überwachung, R-R-Intervall.

Résumé

Limites de la technologie actuelle permettant la surveillance fœtale

On confond les enregistrements permanents à l'aide d'un cardiotocographe avec le concept de surveillance. Il en découle l'un des problèmes permanents à savoir que les enregistrements sont à tous coups surveillés par les cliniciens. Les essais antérieurs simplistes de réaliser de réels appareils de surveillance n'ont pas fonctionné et ces essais ont empêché le developpement d'approches plus sophistiquées que la technologie moderne rend actuellement possible. Dans ce domaine, l'utilisation d'ordinateurs ne permet pas seulement de diminuer la charge de la surveillance par les cliniciens mais elle offre également des avantages quant au stockage des données, quant au transfert des données et pour l'audit. Les professionnels ont manqué la demande, et les fabricants l'offre des avantages de la technologie moderne qui pourrait améliorer notre niveau de soin au cours di travail.

Mots-clés: Audit, auto-corrélation, cardiotocographe, intervalle R.R., ordinateur, surveillance.

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